UNCLASSIFIED

AD NUMBER
AD891847
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited. Document partially illegible.**
FROM: **Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; NOV 1971. Other requests shall be referred to Army Pitman-Dunn Laboratory, Attn: SMUFA-L3200, Frankford Arsenal, Philadelphia, PA 19137. Document partially illegible.**
AUTHORITY
fa, d/a ltr, 21 nov 1973

THIS PAGE IS UNCLASSIFIED

AD891847

DDC FILE COPY

Dn 2

MEMORANDUM REPORT M71-25-1

STRESS CORROSION TESTS FOR ALUMINUM ALLOYS

By

JOSEPH J. GORDON
JAMES V. RINNOVATORE

November 1971

Distribution limited to U.S. Government agencies only Test and Evaluation, November 1971. Other requests for this document must be referred to the Commanding Officer, Frankford Arsenal, Philadelphia, Pa., Attn: SMUFA L3200.

DEPARTMENT OF THE ARMY
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed. Do not return it to the originator.

14

FA-

9

MEMORANDUM REPORT M71-25-1

6

STRESS CORROSION TESTS FOR ALUMINUM ALLOYS .

by

10

JOSEPH J. GORDON
JAMES V. RINNOVATORE

11 Nov 71

12 12p.

16

~~AMCMS Code 502E.11.29400~~
DA [redacted] 1TØ62105A328

Distribution limited to U.S. Government agencies only - Test and Evaluation, November 1971. Other requests for this document must be referred to the Commanding Officer, Frankford Arsenal, Philadelphia, Pa. Attn: SMUFA-L3200.

Pitman-Dunn Laboratory
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

November 1971

142 720

ABSTRACT

Two techniques have been studied for the purpose of developing improved stress corrosion tests for 5083 and 7039 alloys. These are: (1) chemical and electrochemical pretreatments of specimens using a sodium chloride solution prior to alternate immersion (AI); and (2) the use of a salt spray test as a more rapid stress corrosion test method. In addition, AI stress corrosion data have been obtained on 5083-H115 forged material.

The results of tests using the chemical and the electrochemical pretreatments indicate that the time to failure of 5083 and 7039 alloys in AI are unaffected. Electrochemical pretreatments in nitric acid solution appear to be nondiscriminatory in achieving significant reductions in failure times on 5083 alloy.

The use of salt spray on 5083-H131 has no effect on reducing the median time to failure. However, significant reductions in failure time are achieved with the use of salt spray on 7039-T6 alloy when the results are compared with those obtained from AI.

Forged 5083-H115 plate shows no susceptibility to stress corrosion after 12 to 15 months' exposure to AI. The use of thermal stabilization treatments on this alloy significantly increase susceptibility to stress corrosion.

INTRODUCTION

Although the importance of stress corrosion has been recognized for many years, it is only within the last few years the specifications for aluminum alloys have included criteria pertinent to stress corrosion performance. The recent emphasis on stress corrosion of aluminum alloys is due, in part, to the stringent requirements placed on the alloy in critical applications such as the space program and Army materiel.

Aluminum alloys currently used in many military applications are susceptible to stress corrosion because of their high strength and highly alloyed composition. Service failures have been noted in ammunition components, armored vehicles, and helicopter landing gear. Such failures represent a most serious problem and point to the need for continued research in the stress corrosion field.

Work is also needed to improve techniques for evaluating stress corrosion susceptibility. Present tests are lengthy and, on many occasions, the results of these tests have been found to be unrelated to the performance of an alloy under service conditions. Thus, the need exists not only for shorter tests but, also, for more improved testing techniques.

This task was directed toward these needs, with particular emphasis on studies of aluminum alloys 5083 (Al-Mg) and 7039 (Al-Zn-Mg). These alloys are used as armor material because they possess a favorable combination of good ballistic characteristics and a high strength-to-weight ratio. However, it is known that alloys of these compositions are susceptible to stress corrosion cracking, especially in the critical short transverse direction.

The work described in this report consists essentially of two phases. The first phase was concerned with developing an improved stress corrosion test for aluminum alloys 5083 and 7039; the second consisted of experiments in which alternate immersion (AI) stress corrosion data were obtained on 5083-H115 aluminum forged material.

In the studies directed toward developing an improved stress corrosion test, experiments were conducted to measure the effects of chemical and electrochemical pretreatments on the AI failure times of the alloys. The purpose of such pretreatments, which were based on previous work performed by Romans,[1] was to develop a more rapid and reliable stress corrosion test than is available at present. The first phase also included work in which the salt spray technique was evaluated as a more rapid stress corrosion test for alloys 5083 and 7039.

---

[1] H. B. Romans, "Stress Corrosion Test Environments and Test Durations," ASTM STP 425, p 182 (1967).

The purpose of the second phase of work was to generate stress corrosion data which could possibly be incorporated into specifications for forged aluminum alloys for present and future armor applications. Little information is currently available concerning stress corrosion of forged material; most of the stress corrosion data has been obtained from tests on rolled plate.

EXPERIMENTAL PROCEDURE

The alternate immersion technique used to measure stress corrosion performance in the present task has been described in detail in other publications.[2] Briefly, it consists of stressing C-ring specimens to 75 percent of the longitudinal yield strength by constant strain in bending. The specimens, while under stress, are cyclically exposed to a 3-1/2% sodium chloride solution for a 10-minute period, followed by 50 minutes of air drying. The solution temperature is controlled at 73° ± 2° F. Ambient temperature and relative humidity are controlled at 80° ± 2° F and 45% ± 6%, respectively.

In the current study, 0.750 in. diameter C-ring specimens, machined from 1 inch rolled plate, were used. Figure 1 shows a specimen under stress prior to alternate immersion.

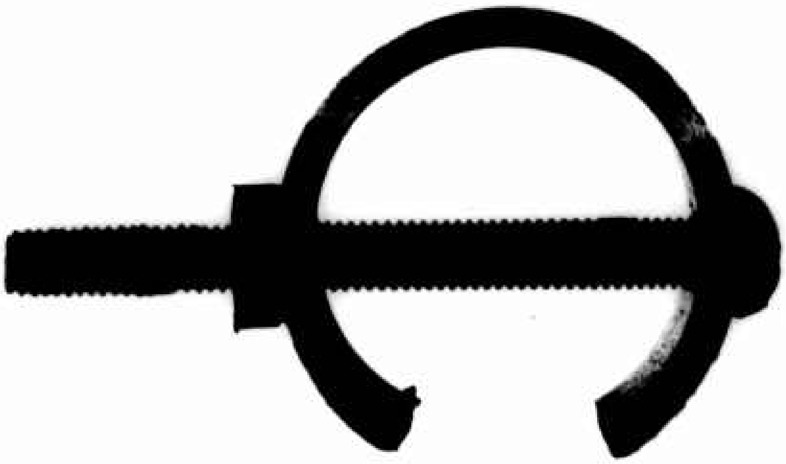

Figure 1. Stressed C-ring Specimen Prior to Testing

Two methods were used for the pretreatment studies. One method consisted of immersing an unstressed specimen in the 3-1/2% NaCl solution for either a continuous period of time or for a cyclic period of 10 minutes' exposure and 50 minutes' air drying. The second method

[2]B. W. Lifka, D. O. Sprowls, and J. G. Kaufman, "Exfoliation and Stress Corrosion Characteristics of High Strength, Heat Treatable Aluminum Alloy Plate," Corrosion, p 335 (Nov 1967).

consisted of electrolytically treating an unstressed specimen for a fixed time in NaCl or in HNO_3. These pretreatments were performed on the specimens prior to alternate immersion.

Specimens tested by the salt spray technique were similar in design to those tested by alternate immersion. C-ring specimens were stressed to 75 percent of their yield strength and placed in chambers which were maintained at 95° ± 2° F and 100% relative humidity. Tests were performed using 5% and 20% NaCl concentrations.

RESULTS AND DISCUSSION

The alternate immersion stress corrosion results on 7039-T6 alloy as affected by surface pretreatments are shown in Table I.

TABLE I.
Effect of Pretreatment on Alternate Immersion Stress Corrosion Results on 7039-T6 Alloy

Lot	Test	Pretreatment on Unstressed Specimen	Avg Median Failure Time (days)
2	18	None	11
2	18	Continuous immersion in 3-1/2% NaCl, 48 hr	9
2	18	Alternate immersion in 3-1/2% NaCl, 48 hr	12
4	36	Electrolytic, 1 N NaCl, 40 ma/in.^{2}, 2 hr	12
4	36	None	15

The results of these tests show that little or no reduction in failure time was achieved by either chemical or electrolytic pretreatments. The differences in median failure tests for the 7039 alloy, shown in Table I, are well within the experimental scatter and, thus, cannot be considered significant.

In the tests performed on 5083, the alloy was cold-worked and thermally treated to produce four different levels of stress corrosion susceptibility. The results are shown in Table II.

In contrast to the results obtained on the 7039 alloy, the results on the 5083 showed that a large effect on failure time was induced by electrolytic pretreatment in HNO_3. However, this pretreatment was nondiscriminatory since failures in alternate immersion occurred after approximately the same time for all four conditions. No effect on failure times was achieved by pretreating electrolytically with NaCl.

TABLE II.
Effect of Pretreatment on Alternate Immersion Stress Corrosion Results on 5083 Alloy

Condition: Cold Worked	Condition: Aged °F	Condition: Aged Hr	Pretreatment on Unstressed Specimen	Avg Median Failure Time[a] (days)
20%	250	4	None	80
20%	250	4	Electrolytic, 1 N NaCl, 40 ma/in.^{2}, 1 hr	b
20%	250	4	Electrolytic, 30% HNO_3, 6 a/in.^{2}, 10 min	3
30%	275	4	None	3
30%	275	4	Electrolytic, 1 N NaCl, 49 ma/in.^{2}, 1 hr	5
30%	275	4	Electrolytic, 30% HNO_3, 6 a/in.^{2}, 10 min	1
30%	225	4	None	No failure, 122 days
30%	225	4	Electrolytic, 30% HNO_3, 6 a/in.^{2}, 10 min	1
40%	250	4	None	11
40%	250	4	Electrolytic, 30% HNO_3, 6 a/in.^{2}, 10 min	1

[a]Avg median failure time for one lot of five tests.
[b]One specimen failed after 12 days; remainder still OK after 497 days.

The results of the salt spray tests on 7039 and 5083 alloys are shown in Table III. Alternate immersion data are also shown for comparison.

TABLE III.
Comparison of Salt Spray Test Results with Alternate Immersion (AI) Results

Alloy	Lot No.[a]	Median Failure Time (days): Alternate Immersion	Median Failure Time (days): Salt Spray 5% NaCl	Median Failure Time (days): Salt Spray 20% NaCl
7039-T6	60	6	2	1
	28	6	1	1
	12	10	5	5
	31	12	8	6
	94	17	9	6
	76	19	5	2
	93	25	4	2
	22	31	7	3
5081-H131	b	Discontinued after 365 days; no failure.	Discontinued after 187 days; no failure.	

[a]Nine specimens per lot.
[b]Five lots were tested.

In each of the lots of 7039 alloy tested (9 specimens per lot), the salt spray tests (using NaCl concentrations of 5% and 20%) reduced median failure times considerably as compared with the alternate immersion tests. The reduction in failure time induced by the 20% concentration was greater than that induced by the 5% concentration.

Although these results are encouraging, further tests would be necessary in order to establish the validity of this test method. Additional tests should be performed on specimens having various levels of susceptibility to stress corrosion as measured by alternate immersion. In addition, alloy microstructure and processing variables should be examined more closely since scatter in stress corrosion test data can be, in part, attributed to variations in these parameters.

The results of both the AI and the salt spray tests on 5083-H131 alloy indicate that the alloy is immune to stress corrosion cracking. These results suggest that where alloys are normally resistant to stress corrosion, as indicated by AI tests, the use of a salt spray test as a substitute for the AI test offers no advantages.

In the second phase of the work, which was concerned with tests on forged material, specimens of 5083 forged plate were tested by AI. Initial tests were performed on four lots of the 5083 in the H115 temper. The results are shown in Table IV.

TABLE IV.
Results of Tests by Alternate Immersion in 3-1/2% NaCl
on Forged 5083 Alloy

Lot No.	Temper	Test Direction	Median Failure Time (days)
02	H115	Longitudinal	No failure after 365 days
02	H115	Short transverse	No failure after 365 days
03	H115	Longitudinal	No failure after 365 days
03	H115	Short transverse	No failure after 365 days
75	H115	Longitudinal	No failure after 365 days
75	H115	Short transverse	No failure after 365 days
04	H115	Longitudinal	No failure after 405 days
04	H115	Short transverse	No failure after 488 days
04	6 hr at 275° F	Longitudinal	a
04	6 hr at 275° F	Short transverse	10
04	20 hr at 300° F	Longitudinal	2
05	20 hr at 300° F	Short transverse	2

[a]Two specimens failed after 10 days; tests on remainder still in progress.

After exposure for periods from 12 to 15 months, no failures were observed on specimens stressed in either the longitudinal or short transverse direction. Ten specimens per lot were tested in the H115 temper. They were stressed to 75 percent of their yield strength.

Additional tests were made to determine the effect of thermal stabilization treatments on the stress corrosion resistance of the alloy. One lot (04) of material was tempered at two different temperatures and times and retested. The results are also shown in Table IV. Note that the stabilizing treatments produced a highly susceptible condition in the alloy.

These data are comparable to what is found from tests on thermally stabilized 5083 rolled plate, which also has poor resistance to stress corrosion cracking.

SUMMARY

The results of this work have shown that chemical and electrochemical pretreatments using a sodium chloride solution on 7039-T6 alloy have no effect on accelerating failure in alternate immersion tests. It was shown also that no effect was achieved using an electrochemical pretreatment with sodium chloride on alloy 5083.

A large effect on reducing failure times was induced by the use of HNO_3 in an electrochemical pretreatment on the 5083 alloy, as tested in four cold-worked and aged conditions. However, one disadvantage of this pretreatment is that the times to failure for all four conditions were identical.

The results of the salt spray tests on alloy 7039-T6 were found to be encouraging. Median failure times of the alloy were reduced by these tests from about 60% to 90% when compared to the results obtained from the standard AI tests. Additional work using salt spray tests on 7039 material should be performed. The stress corrosion characteristics of the alloy heat-treated to provide various levels of susceptibility should be measured by the salt spray technique. On the other hand, additional salt spray tests on alloy 5083 should not be performed since this technique had no effect on reducing the time to failure.

The results of the AI tests on 5083-H115 forged material showed that the alloy has excellent resistance to stress corrosion. No failures were achieved after 12 to 15 months' exposure. Thermal stabilization treatments on the alloy, however, considerably lowered its resistance to stress corrosion cracking.

Distribution List
Not Filmed

Page 7 thru 11

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Frankford Arsenal, Philadelphia, Pa. 19127	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP N/A

3. REPORT TITLE

STRESS CORROSION TESTS FOR ALUMINUM ALLOYS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Research Report

5. AUTHOR(S) (First name, middle initial, last name)

Joseph J. Gordon
James V. Rinnovatore

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1971	11	Two

8a. CONTRACT OR GRANT NO. AMCMS Code 502E.11.29400 b. PROJECT NO. DA Project 1T062105A328 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Frankford Arsenal Memorandum Report M71-25-1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Distribution limited to U.S. Government agencies only - Test and Evaluation, November 1971. Other requests for this document must be referred to the Commanding Officer, Frankford Arsenal, Philadelphia, Pa., Attn: SMUFA L3200.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Frankford Arsenal In-house Laboratory Independent Research Program

13. ABSTRACT

Two techniques have been studied for the purpose of developing improved stress corrosion tests for 5083 and 7039 alloys. These are: (1) chemical and electrochemical pretreatments of specimens using a sodium chloride solution prior to alternate immersion (AI); and (2) the use of a salt spray test as a more rapid stress corrosion test method. In addition, AI stress corrosion data have been obtained on 5083-H115 forged material.

The results of tests using the chemical and the electrochemical pretreatments indicate that the time to failure of 5083 and 7039 alloys in AI are unaffected. Electrochemical pretreatments in nitric acid solution appear to be nondiscriminatory in achieving significant reductions in failure times on 5083 alloy.

The use of salt spray on 5083-H131 has no effect on reducing the median time to failure. However, significant reductions in failure time are achieved with the use of salt spray on 7039-T6 alloy when the results are compared with those obtained from AI.

Forged 5083-H115 plate shows no susceptibility to stress corrosion after 12 to 15 months' exposure to AI. The use of thermal stabilization treatments on this alloy significantly increases susceptibility to stress corrosion.

DD FORM 1473, 1 NOV 65 — REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Aluminum Alloys						
Stress Corrosion						
Alternate Immersion						
Salt Spray						